9. (Amended) A cutting article which comprises the amorphous metal alloy strip having a plurality of an articulated topographical definitions according to claim 2.

11. (Amended) An article which comprises a plurality of self-nesting amorphous metal alloy strips, each of said strips being a generally planar, cast amorphous metal strip and having an articulated topographical definition at a depth greater than the strip thickness produced thereon by application of selected forces that induce permanent deformation.

12. (Amended) An article according to claim 11, said article being a wound transformer core.

13. (Amended) An article according to claim 11, said article being a stacked transformer core.

REMARKS

In order to emphasize the patentable distinctions of applicant's invention over the prior art, claim 1 (and claims 2-9, dependent thereon) have been amended to recite (i) that the amorphous metal is a strip; (ii) that the strip is subjected to selected forces that induce permanent deformation; (iii) that the permanent deformation results in deformations of the order of the thickness of the amorphous metal strip; and (iv) that the strip is depressed on one side and correspondingly protrudes on the other side. This condition of the strip is shown in Figs. 2-4 of the drawings. Claim 4 has been amended to depend from claim 1, and claim 5 has been amended to depend from claim 4. In addition, claims 4 and 5 have been amended to recite that the amorphous alloy is <u>defined by</u> the formula set forth therein. Dependent claims 2-9 have been amended, for the sake of consistency, to call for an amorphous metal alloy <u>strip</u>. Claim 10 has been cancelled, without prejudice, to expedite prosecution of this application. Claim 11 (and claims 12-13 dependent thereon) have been amended to recite (i) that the article comprises a plurality of self-nesting amorphous metal alloy strips; (ii) that each of the strips is a generally planar, cast amorphous metal strip; (iii) that each strip has an

articulated topographical definition at a depth greater than the strip thickness; (iv) that the articulated topographical definition is produced on each of the strips by application of selected forces; and (v) that application of the selected forces induces permanent deformation. Each of these amendments is clearly supported by the original specification. A redline document highlighting the amendments to the claims and an unmarked (clean) copy of the amended claims are enclosed herewith.

As pointed out by the original specification, 3-dimensional features are formed on a planar, nominally 2 dimensional, amorphous material after it is cast in a flat sheet form by the application of plastic deformation forces. The protrusions and depressions are large, as compared to the strip thickness (see Figs. 2-4). As a result, the protrusions nest or interlock with depressions of an adjoining strip to create laminations. This relationship is discussed at page 4, line 18 of the specification. In addition, the tips of the protrusions of a plastically deformed flat sheet can be lopped off. With this arrangement, there is created a cutting edge for an abrading tool (see page 12, line 7 of the specification). These protrusions and depressions are typically created by subjecting a planar sheet of cast amorphous metal to plastic deformation forces provided by a male/female die set. (See page 15, lines 13-21 of the specification). The restriction "produced by application of selected forces that introduce permanent deformation" is fully supported by page 4, lines 16-25 of the original specification. **Such articulated topographical definitions are created by the application of selected forces to a generally planar (2-dimensonal) amorphous metal foil or ribbon. These selected forces introduce permanent deformations in the ribbon that produce a non-planar (3-dimensional) amorphous metal foil or ribbon. Such deformations can include a geometric pattern, texture, profile or other feature, collectively referred to as "articulated topographical definitions". With respect to such articulated topographical definitions, it is required only that there be <u>introduced permanent deformations</u> which will <u>distort or distend</u> the generally planar amorphous metal foil or ribbon to provide a permanent non-planar three-dimensional profile.**

There are significant advantages to creating "articulated topological definition" by plastic deformation of a flat as cast sheet as compared to casting an " articulated topological definition" article of the type disclosed by Narasimhan. Specifically, Narasimhan uses a casting chill substrate, having depressions, which are replicated by the cast strip. In this manner, Narasimhan produces protrusions on the bottom side of the strip, and depressions on the topside thereof. Since the bottom of the chill wheel traverses at a lower casting velocity than the top of the chill wheel, the cast strip inherently acquires a curvature, which is very nearly the same as that of the chill wheel. Clearly, such a strip with three-dimensional character is not flat. It cannot be laid on another strip to produce a lamination. Moreover, the tops of the protrusions cannot be easily machined to create an abrasion tool. On the other hand, material produced by plastic deformation of a previously cast, flat sheet still preserves its flatness in spite of its "articulated topological definition". Such material can be laid over other strips with articulation to create a laminate. It can be readily machined to create an abrasion tool. Significantly, these advantageous features are not afforded by Narasimhan's product. It is therefore submitted that the product called for by applicants' claims has substantially different geometric features than those disclosed by Narasimhan.

There also exist significant magnetic property differences as a consequence of plastic deformation. Plastic deformation results in slip bands along which easy magnetization occurs. The "articulated topological definition" is greater than the thickness of the strip, so that magnetic domains align along the slip bands. This alignment is discussed in Amorphous Metallic Alloys, Edited by F.E. Luborsky, Pub. Butterworths, 1983, pages 313-314; see, in particular, the section entitled "Roll-Induced Anisotropy". A copy of the "Roll-Induced Anisotropy" chapter is enclosed herewith. Clearly, the magnetic properties of the cast Narasimhan product are very different from those afforded by plastically deformed strip having "articulated topological definition", as called for by applicants' amended claims 1-13. The effect of slip bands on the hardness and other mechanical properties of applicants' claimed strip is minimal. [illegible]

More specifically, the product of claims 1-13, as amended, is restricted to a strip produced by a particular process. That process requires the preparation of geometrically articulated amorphous alloys by applying force to permanently deform a planar, amorphous metal sheet with depressions and protrusions greater than the strip thickness. It does not include products produced by direct quenching from a melt. The products, which result from application of selected forces to induce permanent deformation, produce 3-dimensional shapes from a generally planar 2-dimensional ribbon. These geometrically articulated amorphous metal shapes are structurally relaxed due to the absence of directional thermal contraction stresses. As a result, the geometrically articulated amorphous metal shapes are endowed with superior mechanical properties, including exceptional cutting capability and excellent magnetic properties. On the other hand, as quenched products said to have geometrical articulation are in an un-relaxed state, as shown in Fig. 1 of the specification. They do not possess superior magnetic properties or cutting properties, since internal stresses are additive to applied stresses. The magnetic and mechanical properties of applicants' claimed geometrically articulated amorphous strip, which is produced by mechanical forming processes, are superior to properties produced by direct quench methods. In addition, casting angular articulation, similar to hexagonal geometrical articulation as shown in Fig. 2A, generally results in poor reproduction due to melt accumulation along angular edges. This melt accumulation behavior, as well as the poor reproduction of the pattern, is acknowledged by USP 4,322,848 to Narasimhan (see col. 1 line 60 through col. 2 line 17). By way of contrast, the mechanical deformation process used to produce applicants' strip does not have any of these limitations, since the metallic glass essentially flows along the shape of the die. Moreover, non-periodic structures cannot be produced by the Narasimhan process, since the geometrically articulated amorphous metal invariably has a periodicity, created by the circumference of a quench wheel or belt. Clearly, the permanent deformation of amorphous metal strip to create geometrically articulated amorphous metal alloys affords definitive advantages upon which patentability can be predicated.

Claims 1-4 and 6-9 were rejected under 35 U.S.C- 102(b) as being anticipated by US Patent 4,332,848 to Narasimhan.

The Examiner has stated that Narasimhan discloses glassy metal strips having a composition within the limitations of claim 4, and which contain a repeating geometrical pattern of structurally defined protuberances and/ or indentations. With respect to claims 8-9, the Examiner's has taken the position that suitability of a material for abrasive or cutting purposes is directly related to the composition, shape, and relative hardness of the material being abraded or cut; since all of these parameters are the same in the prior art or the claimed invention, the claimed limitations are inherent in the Narasimhan material.

This statement of the Examiner is, respectfully, traversed. There are strong differences between the geometrically articulated 'as cast' amorphous material and that produced by permanent deformation according to the subject invention. In the process disclosed by USP 4,332,848 to Narasimhan, the chill wheel is designed so that the melt can flow and replicate the wheel's shape during casting (see col. 1, lines 60 through col. 2 line 17). In that process, quench wheel depressions have different casting velocities due to wheel radius reductions at the locations of the depressions. This causes the geometrically articulated amorphous material to have a permanent curvature akin to that of the chill wheel. If the geometrically articulated ribbons are straightened by application of force, the ribbon tears or flattens out at these geometrical articulations. Non-periodic geometrical articulation cannot be produced by the quenching process, since the quench wheel surface is periodically brought under the casting nozzle. The 'as cast' ribbons have trapped internal stresses induced during quenching. Such stresses are thermal contraction stresses that have different values along different directions of the ribbon. Mechanical properties of the ribbons are correspondingly reduced due to the additive nature of the internal stresses with applied stresses. In addition the

magnetic properties are reduced owing to these internal stresses, since most magnetic alloys are magnetostrictive.

The geometrically articulated strip defined by applicants' claims 1-4 and 6-9, as amended, is clearly identifiable from an as-cast strip. Unlike an as-cast strip, the geometrically articulated strip of applicants' claims 1-4 and 6-9, as amended, exhibits (i) an absence of internal stresses; (ii) superior magnetic properties; (iii) non-periodic geometrical articulations; and 4) preservation of strip flatness. The geometrical articulations called for by applicants' claims are much larger structures, having thickness greater than the thickness of the amorphous ribbon (see, for example, Fig. 2B, 3B and 4 of applicants' specification).

Narasimhan uses grooves or indentations in the casting wheel to cast a sheet of planar flow cast strip, which has protrusions on one side and corresponding indentations on the other side. Since the depressions in the casting wheel translate at a reduced casting speed, these amorphous sheets with three-dimensional character cannot be laid flat or stacked in any manner to produce a usable stack. By way of contrast, the strip defined by applicants' claims produces these "articulated topological definitions" by plastically deforming a flat, cast sheet <u>subsequent to the casting operation</u> using heated ribbon or a heated die set. The advantage of using this mode of creating "articulated topological definition", as compared to Narasimhan's method, is that the <u>flatness of the sheet is preserved</u>, making possible the subsequent nesting of strips or lopping off of protrusions to produce a tool. The strips cast by Narasimhan's process have essentially the curvature of the wheel superimposed thereon; and they cannot be stacked or subject to lopping off operations.

The Narasimhan strip is an 'as-cast' material. As such, it is devoid of any slip lines. By way of contrast the 'articulated topological definition' of strip delineated by applicants' claims is entirely created by <u>plastic deformation</u>, and <u>has slip lines</u>. The magnetic properties of plastically deformed metallic strips are distinctly different from those of as-cast material, since slip lines participate in defining magnetic domain boundaries, and alter the stress state of the laminates. The easy

magnetization direction is along the slip bands. [see Amorphous Metallic Alloys Edited by F.E. Luborsky, Butterworths, 1983, pages 313-314, Roll-induced Anisotropy]. Therefore, the "articulated topological definition" required by applicants' claims allows laminated nested cores to be manufactured due to strip flatness. In addition applicants' claimed strip has unique magnetic properties, as compared to Narasimhan's strip, which is not stackable due to the inherent curvature of the strip and has inferior magnetic properties, due to being devoid of slip lines. Accordingly, it is submitted that the Narasimhan product is <u>materially different</u> from that called for by present claims 1-4 and 6-9, and essential geometric and magnetic properties of the Narasimhan product differ significantly from those obtained using the strip called for by applicants' claims 1-4 and 6-9.

These structural elements and magnetic properties clearly distinguish claims 1-4 and 6-9, as amended, from those of conventional as-cast ribbon. Products containing the elements defined by present claims 1-4 and 6-9 are differentiated by the presence of superior mechanical and magnetic properties. In addition, the production of geometrical articulations, as defined by applicants' claims, results in geometrical articulation of greater magnitude than that obtained by conventional quenching processes while, at the same time, maintaining strip flatness.

Claim 1, as amended, incorporates restrictions on depth of the articulated topographical definition, being greater than strip thickness produced by application of selected forces to introduce permanent deformation on a generally planar cast amorphous strip. These restrictions clearly distinguish applicants' strip from that of Narasimhan.

Accordingly, reconsideration of the rejection of Claims 1-4 and 6-9 under 35 U.S.C. 102(b) as being anticipated by US Patent 4,332,848 to Narasimhan is respectfully requested.

Claims 1, 2, 6-9 and 11 were rejected under 35 U.S.C. 102(b) as being anticipated by JP 62-250153.

The Examiner has stated that JP '153 reference discloses laminated amorphous metal sheets with a defined surface roughness; and is the full patentable equivalent of the claimed -"articulated

topographical definition". Each of the limitations of claims 6-9 is held to be inherent in the JP '153 materials for reasons as set forth in item no. 8 supra. For these reasons, the products disclosed by JP '153 are said to fully meet the limitations of the instant claims

The JP '153 material has surface roughness which is on only one side of the strip and is on a microscopic scale of 0.2-10 micrometers, so that effective adhesion can be obtained at the created by plastic deformation and being greater than the strip thickness. As amended, claim 1 clearly distinguishes the subject invention from that disclosed by JP '153.

Accordingly, reconsideration of the rejection of claims 1, 2, 6-9 and 11 under 35 U.S.C. 102(b) as being anticipated by JP 62-250153 is respectfully requested.

Claim 5 was rejected under 35 U.S.C.103{a) as being unpatentable over Narasimhan in view of Watanabe et al or Sato et al.

The Examiner has stated that Narasimhan products do not appear to contain element "Z" as defined in instant claim 5. The Watanabe or Sato et al patents indicate that it is conventional in the art to include element "Z" in amorphous alloy strip compositions, in the amounts as defined in the instant claim. Consequently, the Watanabe or Sato disclosures would have motivated one of ordinary skill in the art to produce the Narasimhan products containing an amount of element "Z" as defined in the present claims.

As noted hereinabove, the requirements of the alloy called for by claim 5 involve not only quenchability; but also permanent deformation by forces that create the geometrical articulations. Each of Narasimhan, Watanabe and Sato et al. disclose alloys having additions of element "Z" to improve quenchability; but none of these patentees disclose use of the "Z" element to provide superior permanent deformability upon application of force. On the other hand, the amorphous metal alloy article called for by claim 5, as amended, does not cast geometrically articulated amorphous metal ribbon. Instead, such ribbon is permanently deformed by forces that impress the desired geometrical articulations.

Accordingly, reconsideration of the rejection of Claim 5 under 35 U.S.C. 103(a) as being unpatentable over Narasimhan in view of Watanabe et al or Sato et al is respectfully requested.

Claims 11-13 were rejected under 35 U.S.C. 103(a) as being unpatentable over Narasimhan in view of either Watanabe et al or Bruckner (U.S. Patent 4,853,292).

The Examiner has recognized that Narasimhan does not discuss a plurality of stacked materials or transformer cores, as required by claims 11-13, as amended. However, the Examiner has stated that Both Watanabe and Bruckner indicate it to be conventional in the art to form laminated cores by using a plurality of layers of amorphous metal alloys. Accordingly, it is the Examiner's position that these disclosures would have motivated one of skilled in the art to form the materials disclosed by Narasimhan into the configurations set forth by Watanabe or Bruckner.

Narasimhan discloses as-cast material, which is geometrically articulated by having projections or depressions on a quench surface. Due to the circular or repeating nature of the quench surface only periodic structures are produced; such structures have at least the periodicity of the quench substrate. On the other hand, plastically deformed 3-dimensional shapes of the type required by applicants' claims 11-13, as amended, can be impressed on an amorphous sheet in completely arbitrary non-periodic shapes. An example of a non-periodic geometric articulation is shown in Fig. 3B of applicants' specification. On a quench surface either depressions or projections traverse below the casting nozzle at different casting velocities compared to the general surface of the quench wheel, based on the radius at the projection or depression. Consequently, the depressions are shorter in length compared to the flat portion of the sheet, and the sheet has a curvature similar to that of the quench wheel. Forcing the amorphous ribbon to a flat shape, generally tears the projections cast. This is of course not a problem with belt casting. Accordingly, flat sheets cast on a quench wheel are not available to produce laminations. On the other hand, plastically deformed three-dimensional shapes impressed on a planar amorphous sheet can be

stacked to produce laminations due to the sheet's lack of fixed curvature. The inherent nature of melt flow during a quench casting process creates severe limitations on the geometry of shapes that can be successfully replicated. This is discussed at col. 1, lines 60 through col. 2, line 17 of Narasimhan. If the angles deviate from the values disclosed by Narasimhan, reproduction of the three-dimensional pattern is not replicated. The geometrically articulated amorphous sheet disclosed by Narasimhan is full of thermal contraction stresses. Such contraction stresses compromise magnetic properties and result in non-uniform stress needed to fracture the sheet, since internal stresses are additive with applied stresses. In order to emphasize the salient features of the present invention, claims 11-13, have been amended to require that the articulated topographical definition be produced by application of selected forces that introduce permanent deformation. The geometrically articulated amorphous product required by claims 11-13, as amended, is inherently different from a sheet composed of as-cast material. The problems of geometry, lack of flatness, inherent periodicity of the quench surface, and thermal contraction stresses discussed hereinabove severely limit the application of geometrically articulated, as-cast amorphous metal sheets. In particular, the magnetic properties, cutting ability and wear resistance of as-cast amorphous metal sheets are severely compromised. These factors differentiate the article delineated by claims 11-13, as amended, from the cited references. As a result, the geometrically articulated amorphous metal article required by claim 11-13, as amended, exhibits excellent magnetic and mechanical properties, whereas the as-cast amorphous metal alloys disclosed by Narasimhan do not.

Neither Narasimhan nor Watanabe and Bruckner disclose permanently deformed metallic glass strip having macroscopic geometric articulation for laminated cores. Narasimhan's as-cast amorphous material is unsuitable for producing laminated cores, due to several reasons. First, the thermal contraction strains produce poor magnetic properties. Ribbon curvature, inherently produced when the ribbon is cast on a quench wheel, prevents stackability of as-cast, geometrically articulated amorphous metal ribbons. This stackability problem would impair production of an

article that comprises a plurality of self-nesting amorphous metal strips, as called for by applicants' claim 11. The material taught by Watanabe et al. and Bruckner has microscopic surface roughness (i.e. no more than .3-30 % of the strip thickness, see col. 2, lines 11-23 of Watanabe et al.), not macroscopic geometric articulations (i.e. greater than the strip thickness, see Figs. 2-4 of applicants' drawings), as required by claims 11-13, as amended. Since the articles produced by Watanabe et al. and Bruckner are as-cast products, they contain thermal contraction strains with poor magnetic properties when laminated. By way of contrast, the article of claims 11 to 13 comprises stackable flat ribbons with geometrical articulation in a relaxed state, thereby providing a self-nesting feature not disclosed or suggested by the art applied. The amendment of claim 11, which requires that the amorphous metal strip be permanently deformed to produce an articulated topographical definition at a depth greater than the strip thickness, distinguishes the subject matter of claims 12 and 13 from the cited references. It also distinguishes the subject matter of claim 11, since geometrical articulations caused by permanent deformation have fixed dimensions each of which are greater than the strip thickness, free from edge burs and other imperfections (which are typically found in as-cast products). These features significantly improve stackability, thereby enabling articles having articulated topographical definition to be self-nesting.

For the reasons set forth above, it is submitted that combining the Narasimhan product with the laminations disclosed by Watanabe or Bruckner will, of necessity, result in a poorly stacked lamination, since the articulations would not match from strip to strip owing to the inherent curvature of the as-cast strip. **Large articulations have inherently increased curvature and would not result in a nested lamination, as called for by present claims 11-13. Such a nested lamination stack, and the advantageous features afforded thereby, cannot be obtained unless there is preserved the flatness condition of the strip without melt flow problems inherent to the cast articulated strips with deep structural features produced by Narasimhan.**

Accordingly, reconsideration of the rejection of claims 11-13 under 35 U.S.C. 103(a) as being unpateniable over Narasimhan in view of either Watanabe et al or Bruckner (U.S. Patent 4,853,292) is respectfully requested.

In view of the amendments to the claims and the remarks set forth above, it is submitted that this application is in allowable condition. Accordingly, reconsideration of the final rejection of claims 1-9 and 11-13, as amended, entry of this proposed amendment and allowance of the application are earnestly solicited.

Respectfully submitted,
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What is claimed is:

1. (Twice Amended) An amorphous metal alloy strip having an articulated topographical definition at a depth greater than strip thickness produced on a generally planar, cast amorphous metal strip by application of selected forces that induce permanent deformation.

2. (Amended) An amorphous metal alloy strip according to claim 1 which comprises a plurality of articulated topographical definitions.

3. (Amended) An amorphous metal alloy strip according to claim 1 which comprises a plurality of geometrically repeating articulated topographical definitions.

4. (Amended) An amorphous metal alloy strip according to claim 1, having a composition defined by the formula:

$$M_kY_p$$

wherein:

M is a metal selected from one or more of the group consisting of Fe, Ni, Co, V and Cr;

Y represents one or more elements from the group consisting of P, B and C;

k represents atomic percent, and has a value of from about 70 – 85;

p represents atomic percent, and has a value of about 15 – 30;

5. (Amended) An amorphous metal alloy strip according to claim 4, having a composition defined by the formula:

$$\mathbf{M_aY_bZ_c}$$

wherein:

M is a metal selected from one or more of the group consisting of Fe, Ni, Co, V and Cr;

Y represents one or more elements from the group consisting of P, B and C;

Z is one or more elements selected from the group Al, Si, Sn, Ge, In, Sb or Be;

a represents atomic percent and has a value of from about 60 – 90;

b represents atomic percent and has a value of from about 10 – 30;

c represents atomic percent and has a value of from about 0.1 – 15;

and, a+b+c = 100.

6. (Amended) An abrasive article which comprises the amorphous metal alloy strip having an articulated topographical definition according to claim 1.

7. (Amended) An abrasive article which comprises amorphous metal alloy strip having a plurality of an articulated topographical definitions according to claim 2.

8. (Amended) A cutting article which comprises the amorphous metal alloy strip having an articulated topographical definition according to claim 1.

9. (Amended) A cutting article which comprises the amorphous metal alloy strip having a plurality of an articulated topographical definitions according to claim 2.

11. (Amended) An article which comprises a plurality of self-nesting amorphous metal alloy strips, each of said strips being a generally planar, cast amorphous metal strip and having an articulated topographical definition at a depth greater than the strip thickness produced thereon by application of selected forces that induce permanent deformation.

12. (Amended) An article according to claim 11, said article being a wound transformer core.

13. (Amended) An article according to claim 11, said article being a stacked transformer core.

14. A process for the manufacture of an amorphous metal alloy article having an articulated topographical definition which comprises the steps of:

heating the amorphous metal alloy article to an elevated temperature and subsequently stamping or otherwise deforming the heated amorphous metal alloy article in a die.

15. The process according to claim 14 wherein the die is preheated.

16. The process according to claim 14 wherein the die is a roller die or a stamping die.

17. The process according to claim 14 wherein at last part of the articulated topographical definitions are selectively crystallized.

18. The process according to claim 14 wherein at last part of the articulated topographical definitions are ground to remove a part of the articulated topographical definitions.

19. The process according to claim 14 wherein an abrasive material is adhered to at least the articulated topographical definitions of the amorphous metal alloy article.

Amended Claims – With Markings To Show Changes Made

What is claimed is:

1. (Twice Amended) An amorphous metal alloy ~~article~~strip having an articulated topographical definition at a depth greater than strip thickness produced on a generally planar, cast amorphous metal strip by application of selected forces that induce permanent deformation.

2. (Amended) An amorphous metal alloy ~~article~~strip according to claim 1 which comprises a plurality of articulated topographical definitions.

3. (Amended) An amorphous metal alloy ~~article~~strip according to claim 1 which comprises a plurality of geometrically repeating articulated topographical definitions.

4. (Amended) An amorphous metal alloy ~~article having an articulated topographical definition wherein the amorphous metal alloy has~~strip according to claim 1, having a composition defined by the formula:

$$M_kY_p$$

wherein:

M is a metal selected from one or more of the group consisting of Fe, Ni, Co, V and Cr;

Y represents one or more elements from the group consisting of P, B and C;

k represents atomic percent, and has a value of from about 70 – 85;

p represents atomic percent, and has a value of about 15 – 30;

5. (Amended) An amorphous metal alloy ~~article having an articulated topographical definition wherein the amorphous metal alloy has~~strip according to claim 4, having a composition defined by the formula:

$$M_aY_bZ_c$$

wherein:

M is a metal selected from one or more of the group consisting of Fe, Ni, Co, V and Cr;

Y represents one or more elements from the group consisting of P, B and C;

Z is one or more elements selected from the group Al, Si, Sn, Ge, In, Sb or Be;

a represents atomic percent and has a value of from about 60 – 90;

b represents atomic percent and has a value of from about 10 – 30;

c represents atomic percent and has a value of from about 0.1 – 15;

and, a+b+c = 100.

6. (Amended) An abrasive article which comprises the amorphous metal alloy ~~article~~strip having an articulated topographical definition according to claim 1.

7. (Amended) An abrasive article which comprises~~the~~ amorphous metal alloy ~~article~~strip having a plurality of an articulated topographical definitions according to claim 2.

8. (Amended) A cutting article which comprises the amorphous metal alloy ~~article~~strip having an articulated topographical definition according to claim 1.

9. (Amended) A cutting article which comprises the amorphous metal alloy ~~article~~strip having a plurality of an articulated topographical definitions according to claim 2.

11. (Amended) An article which comprises a plurality of self-nesting amorphous metal alloy ~~articles.~~

strips, each of said strips being a generally planar, cast amorphous metal strip and having an articulated topographical definition at a depth greater than the strip thickness produced thereon by application of selected forces that induce permanent deformation.

12. (Amended) ~~A wound transformer core~~An article according to claim ~~2~~11, said article being a wound transformer core..

13. (Amended) ~~A stacked transformer core~~An article according to claim ~~2~~11, said article being a stacked transformer core.

14. A process for the manufacture of an amorphous metal alloy article having an articulated topographical definition which comprises the steps of:

heating the amorphous metal alloy article to an elevated temperature and subsequently stamping or otherwise deforming the heated amorphous metal alloy article in a die.

15. The process according to claim 14 wherein the die is preheated.

16. The process according to claim 14 wherein the die is a roller die or a stamping die.

17. The process according to claim 14 wherein at last part of the articulated topographical definitions are selectively crystallized.

18. The process according to claim 14 wherein at last part of the articulated topographical definitions are ground to remove a part of the articulated topographical definitions.

19. The process according to claim 14 wherein an abrasive material is adhered to at least the articulated topographical definitions of the amorphous metal alloy article.

Butterworths Monographs in Materials

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atomic pair interactions. According to Iwata,[37] the Néel and Taniguchi theory, for the case of ideal solid solution, must be modified to account for the effect of superlattice and precipitation type interactions. The upper solid line in *Figure 16.13* represents Iwata's relation in which $-kT/2V$ was taken to be 0.6 for the best fit for Fe–Ni–B system. V used here is the atomic pair potential, being positive for superlattice type, negative for precipitation type and zero for ideal solid solutions. Thus, the presently found negative value of V suggests that atomic cohesive interactions among the constituent atoms in the amorphous alloys are stronger between the same kinds of atoms rather than for the different kinds of atom.

We have seen that the field induced anisotropy of amorphous alloys can be interpreted within the framework of the directional atomic pair ordering. The pairs between the different kinds of metal–metal atom are much more important than the metal–metalloid pairs, so that the results of *Figure 16.12* can be satisfactorily explained. Finally, we should note that Becker[39] proposed an alternative model based on a single atom mechanism. The composition dependence predicted agrees well with the results of the Fe–Ni–B alloys[27] without any modification for tendency towards precipitation type clustering or compound formation and it accounts for magnetic annealing effects in iron-only alloys.

16.3.2 Roll-induced anisotropy

Roll induced magnetic anisotropy has been investigated for $(Fe_{1-x}Co_x)_{78}Si_{10}B_{12}$ amorphous alloys by torque measurement (Morita *et al.*[15,40]), and the related extrinsic magnetic properties have been examined for the $Fe_{40}Ni_{40}P_{14}B_6$ amorphous alloy (Luborsky *et al.*[41]). For these alloys, cold rolling is possible up to about 30—40 per cent reduction in thickness, by using a conventional roll technique for thin sheets. It has been found that deformation of amorphous ribbons occurs, on a macroscopic level, in a slip-band-like mode[42], but the amorphous structure, as confirmed by the X-ray diffraction, is not altered.

Roll-induced anisotropy is again uniaxial in the plane of the rolled ribbon, being described with a two-fold symmetry energy E_u^r equivalent to equation 16.3. An example of the torque curves is shown in *Figure 16.6*. Cold rolling will increase the internal strain in the ribbon, but the anisotropy does not seem to be correlated with a magnetostriction–stress coupling effect, because, as seen in *Figure 16.6*, the anisotropy can appear even in the zero magnetostriction alloy. The interesting behaviour of E_u^r to note is the direction of the energy minimum. As seen in *Figure 16.6*, the direction of easy magnetization is always perpendicular to the roll direction, irrespective of the roll direction, i.e., rolling along the long axis or along the width axis. Therefore, the longitudinal reduction results in a hard magnetization along the ribbon axis. The tendency for the decrease in M_1/M_s by rolling found by Luborsky *et al.*[41] for the $Fe_{40}Ni_{40}P_{14}B_6$ amorphous ribbon (*Figure 16.14*) is in reasonable agreement with the result of the torque measurement, where M_1 is the magnetization at 1 Oe (and consequently close to the remanence value) and M_s is the saturation magnetization. This relation between the direction of easy magnetization and the roll direction is attributed to the mechanism by which the slip bands are formed perpendicular to the roll direction. Morita *et al.*[15,40] considered that atomic pair directional ordering may be developed in association with the slip-bands and be responsible for the uniaxial induced anisotropy. On the other hand, Luborsky *et al.*[41] emphasized the importance of a magnetostriction–strain effect, by showing that the decrease in M_1/M_s by rolling can be recovered by a long annealing around 350 °C.

At the present, therefore, the origin for E_u^r is still not clear.

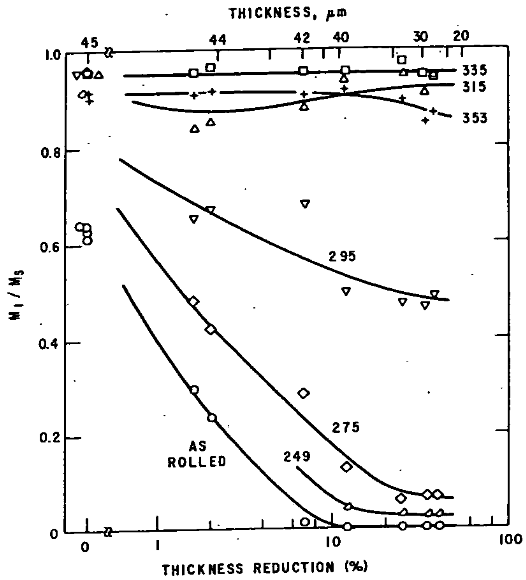

Figure 16.14 Change in ratio of magnetization at 1 Oe/saturation magnetization for METGLAS 2826 as a function of thickness reduction by cold rolling. The subsequent changes on annealing at 249—335 °C are shown with the numbers (after Luborsky *et al*[41])

16.3.3 Strain-anneal induced anisotropy

In the early work on soft magnetic properties[3,30,43] it was found that an application of tensile strain along the ribbon axis makes the magnetization easy, in the case of positive magnetostrictive amorphous alloys. This is due to the simple magnetoelastic effect and can be explained in terms of equation 16.2. Thus, the strain-induced anisotropy is caused to vanish reversibly by removal of the external strain. Contrary to this, strain-anneal induced anisotropy was recently found[44,45,46]. This anisotropy can remain in the strain-free sample after the annealing. Such a strain-annealing effect was first shown by Luborsky *et al.*[47] during a systematic study of the peculiar behaviour of the winding stresses. During annealing of toroidal samples the coercivity and the core losses in iron-rich amorphous alloys remained high, being quite different from the remarkable reduction in losses in the annealed straight ribbon sample (pointed out also by Fujimori *et al.*[49]).

According to the results of Nielsen *et al.*[44,45] and Hilzinger,[46] after annealing under tensile stress, amorphous alloys showed nearly the equivalent magnetic anisotropy perpendicular to the ribbon axis, irrespective of the sign of magnetostriction. *Figure 16.15* shows the magnetization curves[46] of the $Co_{66}Fe_4Si_{16}B_{12}$ amorphous alloy with $\lambda \simeq 0$. The value of the anisotropy constant, K_u^σ, estimated from *Figure 16.15*, was found to increase linearly with increasing tensile stress σ applied during the annealing. K_u^σ is about 160 J/m^3 for $\sigma = 500$ MPa. K_u^σ behaves reversibly in a cyclic annealing with and without tensile stress; K_u^σ rises by stress annealing and disappears completely in annealing free from stress. Furthermore, it is emphasized that K_u^σ can be induced even at higher temperatures than the Curie point, suggesting that the K_u^σ is attributed to the different mechanism from that for the field anneal anisotropy. Nielsen *et al.*[44,45] and Hilzinger[46] considered that K_u^σ may be interpreted as a transient creep effect which has been observed by Kimura *et al.*[48]. Nielsen *et al.* predicted the coupling effect between magnetostriction and compressive strain that is frozen in during the creep process, while, in order to explain the finite K_u^σ observed in the zero

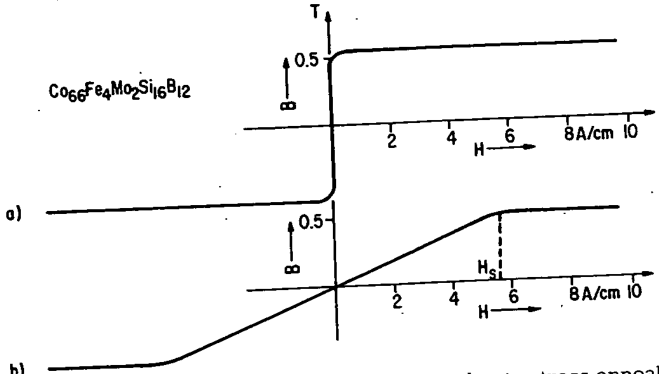

Figure 16.15 Change in magnetization curve due to stress-anneal induced anisotropy for a $Co_{66}Fe_4Mo_2Si_{16}B_{12}$ amorphous alloy: (*a*) annealed at 400 °C for 1 h without stress, (*b*) annealed under tensile stress $\sigma = 272$ MPa (after Hilzinger[46])

magnetostrictive alloy, Hilzinger postulated that a structural rearrangement occurred without any internal stress in the strain-annealed amorphous samples.

The mechanism of K_u^σ is still questionable too. It is of interest that the direction of the induced energy minimum for K_u^σ is perpendicular to the direction of applied tensile stress. This relation is just the same as in the case of cold-roll-induced anisotropy, as already discussed.

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